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ABSTRACT

This study examined the effect of an innovative teaching activity to improve concrete operational thinking skills with preschoolers in Head Start programs. A "learning set" of classification games and seriation games was used to teach the oddity principle and insertion into a series. These games were played with the children using toy ponies and hand puppets as props for a period of 4 months with 15 Head Start 4-year-olds. At the conclusion of this form of instruction, the children were significantly better than a comparison group of Head Start children at both classification and seriation. This superiority extended from problems involving three-dimensional objects to two-dimensional representations of oddity and seriation problems. The children's improvement has positive implications for transition from preschool to grades K-3, as well as for improving skills of at-risk children. (Contains 13 references.) (JPB)

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Cognitive Gains from Extended Play at Classification and Seriation

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Abstract

A "learning set" of 80 classification games and 65 seriation games was used to teach the oddity principle and insertion into a series to 15 Head Start 4-year-olds. These games were played with the children, using toy ponies and hand puppets as props, for a period of four months. At the conclusion of this form of instruction, these children were significantly better than a companion class of Head Start children at both classification and seriation. This superiority extended from problems involving three-dimensional objects to two-dimensional representations of oddity and seriation problems. The children's improvement has positive implications for transition to grades K - 3.

Cognitive Gains from Extended Play at Classification and Seriation

Unidimensional classification is the oddity principle; if several items are identical in some dimension, but one item differs, the one differing is "odd". Unidimensional seriation is ordering objects according to magnitude. Lining up objects in order of size from the smallest to the largest, then inserting a new object in its place within the series, is a good example of the most challenging form of Unidimensional seriation.

These are key thinking abilities that signify readiness for formal schooling [Inhelder & Piaget, 1964/1959]. The ability to classify and seriate at age 5 predicts school success at least through third grade, [Silliphant, 1983]. This prediction applies to achievement as measured by either standardized tests like the Metropolitan Achievement Test, Iowa Test of Basic Skills, or California Achievement Test, or by less formal measures devised by teachers and researchers. This is true even for children matched in psychometric IQ [Dudek, Strobel, & Thomas, 1987].

Kindergartners are, of course, very heterogeneous in their cognitive development. In affluent suburbs, the majority have entered the first phases of concrete operational thought. They can usually determine the relevant difference between items or events when these are simply named and must be represented mentally. For example, when pencils, crayons, chalk, and paper are

mentioned, concrete operational thinkers have no difficulty recognizing that the first three things are similar - they are things <u>with</u> which you can write or mark, while paper is something <u>on</u> which you write or mark. Likewise, such kindergartners can usually order items or events in a meaningful series, or fit things into their place in an existing series. They can do this mentally, verbally, or with physical objects, so long as no more than one dimension or characteristic need be considered. When developed well enough to be employed easily and automatically, these abilities serve 5-year-olds well when it comes to understanding classroom instruction.

However, in the same classrooms, many children are still preoperational thinkers. Their thought is still too often complexive and perceptually bound. That is, irrelevant visual characteristics of objects and tangential connections between events often intrude upon and distort their thinking. These 5-year-olds are often unable to determine which of several things differ in an important respect, and are unable to place an item where it belongs in a series, even when the items are concrete objects that can be examined at length. Such children are at a tremendous disadvantage in kindergarten, where much instruction is predicated upon such simple concepts and is presented verbally. The ability to comprehend what is relevant and what is not, and to understand necessary sequences is at a premium. Children who are

not competitive with their classmates in this respect at the beginning of kindergarten not only do worse academically in kindergarten and Grades 1 - 4, but also appear to experience increased anxiety, internal pressure, interpersonal constraint, and maladaptive sensitivity (Dudek, Strobel, & Thomas, 1987).

Unidimensional classification and seriation are taught in some form in most preschool, kindergarten, and Head Start curricula. For example, some High/Scope key experiences involve classification and seriation. Unfortunately, research shows that, at least for classification, children seldom apply such lessons to items unlike those with which they were taught [Greenfield, 1985; Soraci, et al., 1991]. The experimental literature for generalization of seriation instruction beyond the instructional materials is distinguished by its absence. In any event, instruction in seriation is usually concerned with building series, something that most 3- or 4-year-olds develop on their own. Insertion of items into an existing series is <u>much</u> harder and more advanced (Inhelder & Piaget, 1964/1959). Children are seldom or never instructed in this operation, which marks the transition from preoperational to concrete operational thought.

A remedy for these difficulties is to give children who are lagging behind their peers effective instruction in these critical thinking abilities. If 5-year-olds who are having difficulty understanding kindergarten work receive learning set instruction

on Unidimensional classification and seriation, they subsequently do better on standardized tests of reasoning and academic achievement [Pasnak, et al., 1991; Pasnak, et al., 1996].

What distinguishes learning set instruction is that scores of examples are used. The examples employ many different types of objects, but all involve the same kind of reasoning. Mastering all of the examples produces thorough mastery of the concepts needed to understand them, and the thinking becomes automatic. "Automaticity" is critical; educators and researchers now know that abilities are unlikely to be used and applied until they become automatic [Hasselbring, Goin, & Bransford, 1987]. The power of a learning set to produce automaticity in any thinking ability depends directly on the number and variety of problems in the learning set. Informal learning sets provided by Mother Nature are the way in which most thinking abilities are naturally acquired [Harlow, 1949; Gagne', 1968; Klahr & Wallace, 1973].

Since learning set teaching of Unidimensional classification and seriation helps children struggling to meet the cognitive demands of kindergarten, it should prevent some failures if given to at-risk preschoolers. The old bromide that a stitch in time sometimes saves nine later is part of the central rationale for preschool programs. Moreover, the concrete examples used in learning sets constitute a wide variety of manipulable objects that are interesting to 4-year-olds. However, an early, unreported

effort by the junior author to conduct the instruction with economically underprivileged 4-year-olds was unsuccessful. Although it was conducted in a warm, supportive way by the children's regular teachers, the instruction was too didactic and too much like work, at least as far as these at-risk children were concerned. Hence, for the present project the instruction was modified for Head Start 4-year-olds by making it a form of play.

Play is, for young children, a primary means for engaging and understanding objects, events, and ideas. Games that involve consistent rules shared with other players have a significant role in cognitive development (Eisner, 1990). By evoking thought coupled with activity, language, and creativity, games enable a child to exercise and develop cognitive processes in a way that acceptable and even exciting (Weininger & Daniel, 1992). When games make use of age-appropriate cognitive processes, they can strengthen those processes, making them better understood and more accessible to the child. The context of mastering the game makes the employment of the emerging cognitive abilities a source of satisfaction, and they are employed with more competency and creativity. Accordingly, the presentation of the learning set problems was modified to transform it into forms of play. This learning set "play" at classification and seriation was offered to a Head Start class; results are reported here.

Method

Children Ten Head Start girls and 5 boys - 2 African-American, 8 Latino, and 5 MidEastern - played the games and provided complete data. Their average age was 4 yrs., 6.72 mos., SD = 2.70 mos. Eight girls and 7 boys from a similar Head Start class provided comparison data. One was Asian, 6 African-American, 5 Latino, and 3 MidEastern; their ages averaged 4 yrs, 10.47 mos., SD = 2.03 mos.

Materials Eighty classification games were presented in 80 small trays, each containing four small objects. The objects varied widely; most were small toys or common household, hardware, drugstore, grocery, sewing, craft, or nature items. In 20 trays there were three objects identical in shape and one differing only in shape. Twenty more trays had three objects of the same type and one different, i.e., three different kinds of nuts and a brown rock, or three different plastic numbers and a plastic letter. Ten more trays had one large and three small objects identical except for size, e.g., one large and three small paperclips, three large buttons and one small one, etc. Conversely, 10 trays had one small and three large objects - one small and three large paperclips, one small and three large buttons, etc. Twenty trays each had four identical objects; three objects were oriented in one direction, one in another when the games were played.

For seriation, 65 trays held 3 - 8 ordinary, everyday objects varying in length, width, height, or overall size. Fifteen trays held three objects, 20 held four, 15 held five, five trays held six, five held seven, and five held eight.

Procedure The instruction was modified by teaching the children in groups of three instead of six, and using a game format. The teacher, an African-American college senior, acted the role of a small toy pony or a hand puppet. Speaking in the [high-pitched] voice of the pony or puppet, she invited three children to play with her trays of objects. They were given ponies and asked to pretend that they were the ponies, or to pretend that the puppet was real and to talk to it. Each child was given a tray of objects and asked to choose or have their pony choose the object that was different, or have their pony stamp on it, or kiss it, etc. Correct choices were rewarded with praise and "high fives" or mane-shaking or tail-shaking or other tricks from the teacher's pony or puppet. Children [or ponies] making mistakes got extra chances, with playful hints and coaching from the teacher and her pony or puppet. Children also learned from each other, as trays were rotated among them, and laughter was common in these 10-minute sessions.

First the games involved selecting the odd shape. When a child [or the child's pony] excelled at these 20 games, the games changed to selecting the odd size, then the odd type, then the odd

orientation. Next children played a form of "blind man's bluff" by reaching into a box and solving by touch shape or size oddity problems that they had previously solved visually. In this "successive" classification, objects must be examined and considered one after the other in an orderly way, since they cannot all be seen simultaneously.

Seriation games began next. Children lined up three objects in order of size until they were proficient at it, then four objects. When this was easy, they were given three of the four objects they had just seriated, while the puppet or pony held back a middle-sized one. After seriating these three, the children were given the fourth, and the puppet or pony helped them insert it into the series correctly. After mastering this, children moved on to inserting a 5th object into a series of 4, a 6th into a series of 5, etc. until they could easily insert an 8th into a series of 7.

For posttests, each child played 16 classification [4 shape, 4 size, 4 type, and 4 orientation] and 10 seriation games [two games with 3 objects, two with 4, etc., up to two with 7 objects, with insertions] with brand new objects. This tested their ability to apply their reasoning to problems involving new three-dimensional objects. If successful, they would demonstrate "near" generalization; although new and physically different from the instructional objects, these games still required the children to

classify and seriate 3-D objects. They also played 30 oddity games and 12 seriation games [without insertions] composed of drawings and photographs, testing their ability to apply their reasoning to problems in the two-dimensional format kindergartners commonly encounter. These included 12 classification problems copied from the Otis-Lennon School Ability Test [O-LSAT] for kindergartners. Success on these games would demonstrate "far" generalization - applying the principles learned in greatly different formats.

Results

In their play [average number of sessions = 84.36, SD = 9.88] before posttesting, 7 children mastered all the games, 4 mastered all classification and some seriation games, and 4 stopped before mastering successive classification.

These children did significantly better overall [all measures combined] than the 15 comparison children, $t[28] = 2.03$, $p<.03$, whether tested with everyday objects, $t[28] = 2.23$, $p<.02$, or with 2-dimensional figures unlike anything used in play, $t[28] = 1.98$, $p<.03$. Their superiority extended to the O-LSAT items, $t[28] = 1.73$, $p<.05$. They were significantly better at classification, $t[28] = 2.34$, $p<.05$, but not, as a group, much better at seriation, $t[28] = .77$, $p>.05$. Only the 7 children who played all

65 seriation games did significantly better than the comparison children at seriation, $t[20] = 2.72$, $p<.01$.

Discussion

The children's success in applying these reasoning abilities to 2-dimensional figures indicates that they will successfully apply their reasoning to paper and pencil work in kindergarten. Likewise, their superiority on O-LSAT questions indicates a greater likelihood of academic success, since that is what O-LSAT scores predict. Because these 4-year-olds were not given the whole O-LSAT, it is uncertain whether they would match the gains the learning set produces for 5-year-olds on other O-LSAT scales. But they should, since for kindergartners such learning sets produced broad gains not tied to any particular O-LSAT or WPPSI subscale.

Although it is possible that these children were superior to the comparison children at the outset, there is no reason to think so, because there was no selection bias for these Head Start classes, which met simultaneously in adjoining classrooms, and the only observable difference, age, favoured the control group.

Modifying the learning set approach to suit 4-year-olds was largely but not entirely successful. Successive classification stymied four children temporarily and four others entirely, denying them benefits from the seriation games. The successive

classification games should have been made easier, so all children could profit fully from the seriation activities.

This research indicates that, when made age appropriate, the learning set approach can effectively teach the oddity principle and the ability to insert successfully into a series to at-risk 4-year-olds. The age-appropriate modification is to have, for a period of months, daily 10-minute periods of play that necessitate successful classification or seriation. Such play, when it involves scores of concrete examples of the principles to be learned, produces learning that generalizes far beyond the instructional materials and produces better classification and seriation even in very different formats.

The success of learning sets in producing far generalization, and the necessity of using the scores of concrete exemplars they entail, is firmly grounded in educational and psychological theory. Empirically, it turns out then when children learn to solve any one problem involving a new principle, they do so in part by extinguishing or abandoning many tendencies that would produce errors. In the context of an oddity problem, these include such things as selecting the largest or brightest or most interesting item, or the one encountered first. As errors are noted and the child helped to make corrections, these tendencies are unrewarded and disappear. But, this disappearance or extinction is closely tied to the items comprising that particular

problem. When a new oddity problem is presented, the error-producing tendencies reappear at nearly full strength [Harlow, 1959]. They will be weakened again through trial and error and feedback as the new problem is solved, and will appear with slightly less strength when another new problem is presented. If this process is continued with many problems for many days, the common error-producing tendencies are completely extinguished, and do not spontaneously reappear.

At the same time, young children may lack the supporting abilities they need to grasp relationships more advanced than those they presently understand. These supporting abilities typically include proper observational and comparison techniques, as well as some conceptual foundations [Gagne, 1968]. Through a long experience of motivated trial and error rewarded with discovery and feedback, these supporting abilities are gradually developed and strengthened, in the same way that learning usually occurs.

Two other keys to the importance of using numerous very variable exemplars are stimulus generalization and stimulus independence. Stimulus generalization is the tendency and ability to recognize physical or perceptual similarities between problems or situations. This recognition greatly eases the application of principles learned in one context to another. This, of course, is exactly what is wanted when a child is taught some new ability.

The use of widely different examples in instruction, rather than a relatively small number of perfectly fine examples, greatly increases the chance that some slight physical resemblance to a problem already experienced and understood will aid the child in applying the same reasoning to a new one. Stimulus independence is the other side of the coin. When children are first taught some new idea their ability to employ it is closely tied to characteristics of the examples with which they were taught. But seriating straws of different lengths bear scant resemblance to seriating identical jars whose contents have different weights. To be successful in this new application, the child's thought must be applied to objects with quite different physical characteristics than those experienced before. The ability to break the bond to physical characteristics of the original problems and apply the principles learned to very novel and physically different problems is to show stimulus independence. Learning sets develop this independence by constantly presenting a child with new, physically variable problems while the learning is occurring. In this way, learning sets mimic the widely varying examples with which Mother Nature usually helps a child to develop more advanced thinking [Klahr & Wallace, 1973].

In sum, it appears that when employed in a game format, the learning set approach can help at-risk 4-year-olds develop their abilities to seriate and to classify on one dimension, and to

generalize these abilities to problems rather different from those used in the instruction. The importance of such gains rests, of course, on the importance of Unidimensional classification and seriation in such children's thinking. Since [1] these abilities are keys to a stage transition in the development of intelligence, [2] their strength at entry to kindergarten predicts later school success, and [3] strengthening them is an effective remediation when children have trouble, there is reason to hope that such guided play will help these at-risk children make the transition to school successfully.

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Table 1

Mean Cognitive Scores for Experimental and Comparison Groups

Learning Set Group			Comparison Group	
2-D Items	3-D Items		2-D Items	3-D Items
		Classification		
18.8	10.3		14.2	7.3
		Seriation		
6.2	7.9		5.3	6.7
		Sums		
25.0	18.2		19.5	14.0
Classification Total		29.1		21.5
Seriation Total		14.1		13.0
All Problems		43.2		34.5

Author Note

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